Bryophyte diversity in a remnant upland rainforest on the Atherton Tablelands, Queensland, Australia

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Abstract

Bryophytes are an important but neglected component of the flora of the Australian Wet Tropics bioregion. In particular, the bryophyte flora of complex notophyll vine forest 5b, also known as Mabi forest, that occurs on fertile basaltic soils in the upland regions of the Atherton Tablelands, Queensland has not been thoroughly examined, despite the endangered status of this forest type. To address this information gap, we collected bryophytes using a floristic habitat survey method where we sampled a wide range of microhabitats and substrates in a ~6 ha patch of Mabi forest within Hallorans Hill Conservation Park, Atherton. We collected 202 bryophyte specimens, and identified 44 species of moss, 41 species of liverworts, and two species of hornworts. Substrates included tree bark and twigs (epiphytic – 66.7% of bryophyte species), rock (epilithic – 41.4%), decaying logs (epixylic – 31%), soil (terrestrial – 12.6%), and on leaves (epiphyllous – 3.4%). Around 30% of species occurred on multiple substrates. The high bryophyte diversity recorded in our survey highlights the need for additional bryophyte surveys in Mabi forests in the Wet Tropics, as well as investigations into their ecology.

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Introduction

Tropical forests are strongholds of diversity of bryophytes – a group of non-vascular land plants that includes mosses, thallose (leafless and body consisting of a thallus) and leafy liverworts, and hornworts – because of the variety of micro-habitats that exist within them. These microhabitats are characterised by varying amounts of direct and indirect light, heat, availability of water, nutrients and their sources, and chemical and physical properties of substrates (Pócs 1982). Available substrates for bryophytes include, but are not limited to, the bases of large trees, decaying logs, emergent rocks in streams, and the surfaces of living leaves, where epiphyllous bryophytes occur in especially humid environments (Pócs 1982; Richards 1988).

The Wet Tropics bioregion of north-eastern Australia (abbreviated here as the Wet Tropics) is an excellent example of the high bryophyte biodiversity supported in tropical areas (Ramsay & Cairns 2004; Cairns *et al.* 2019). Broken down by bioregion, the Wet Tropics was found to have the greatest species richness in Australia for both mosses and liverworts, with particularly high values along the coast, likely because of the affinity of bryophytes for moisture (Stevenson *et al.* 2012). Because of the long evolutionary history of the Wet Tropics, bryophytes of the bioregion also exhibit high endemism, in common with the vascular flora of the region (Ramsay & Cairns 2004; Stevenson *et al.* 2012). In line with these findings, a recent review on the diversity of mosses in the Wet Tropics found over 410 species from 170 genera and 60 families (Cairns *et al.* 2019).

Studies on bryophytes of the Australian Wet Tropics have largely been concerned with taxonomic revisions and descriptions of new species, with little research on the community diversity of bryophytes within specific rainforest types (Ramsay & Cairns 2004; Tomasko *et al.* 2024). This dearth of information is lamentable considering that the Wet Tropics encompasses a wide variety of rainforest types, categorised by leaf size, life-form spectra, canopy cover and elevation (Tracey 1982). Each forest type could potentially offer a different range of substrates for bryophytes to occupy, which would in turn contribute to the bryological diversity of the bioregion (Ramsay & Cairns 2004). For instance, Mabi forest, or complex notophyll vine forest 5b as described by Tracey (1982), is one structural type of rainforest found in the Wet Tropics, distinguished by having a mix of deciduous and evergreen species, basaltic soil, complex understory, and which also receives lower rainfall than other rainforest types (Wet Tropics Management Authority n.d.; Australian Government n.d.). This unique rainforest type provides habitat for many threatened plant and animal species, including Lumholtz's Tree-Kangaroo (*Dendrolagus lumholtzi*) (Australian Government n.d.). Indeed, the name Mabi is derived from the local Aboriginal term for the Lumholtz's Tree-Kangaroo (Campbell 2014).

Mabi forest is a critically endangered ecosystem, with only four percent of its original extent remaining after decades of farming, logging, and grazing (Campbell 2014; Lynch *et al.* 2020). The *c.* 950 hectares remaining are fragmented patches of degraded forest, spared from agricultural clearing due to rockier soil (Lynch *et al.* 2020). While the Queensland Government protects these areas and promotes preservation and restoration efforts, introduced animal species, weeds, and isolation effects still threaten the ecosystem's survival (Department of Environment and Science 2020).

Despite recognition of the ecological significance of Mabi forest, there has not been any systematic survey of the bryophyte flora of this rainforest community, other than an informal collection carried out by bryologists Andi Cairns and David Meagher in 2013 (Cairns & Meagher, unpublished data). An understanding of vegetation composition is critical to evaluating ecosystem health, and bryophytes may function as important ecological indicators of forest integrity (Frego 2007), pollution levels (Zechmeister *et al.* 2003), and climate change (Gignac 2001), thus knowing which species exist in Mabi forest is important (Lynch *et al.* 2020). Furthermore, the ability of bryophytes to colonise disturbed areas makes them important components of restoration efforts (Miyashita 2013). By establishing a baseline bryophyte collection from a remnant patch of Mabi forest in the Atherton Tablelands, we hope to contribute to an improved understanding of the bryophyte communities in the Wet Tropics, stimulate further research into specific rainforest types, and provide valuable data for protection and restoration.

Methods

Study area

The survey was conducted within a remnant patch of Mabi forest within the eastern part of Hallorans Hill Conservation Park nestled within the residential area of the town of Atherton on the Atherton Tablelands, Queensland (17°15'59"S, 145°29'37"E; altitude 765 m to 866 m; Fig. 1). The mean monthly minimum and maximum temperatures at Atherton range between 10.4°C and 28.9°C and annual rainfall between 1300 and 1600 mm (Bureau of Meteorology 2023).

Hallorans Hill is a conical-shaped shield volcano that formed during the Tertiary and Quaternary periods (Whitehead *et al.* 2007). The geology is basaltic, but compared to the surrounding flats, the soils found on Hallorans Hill contain a high percentage of scoria, and bear more similarity to

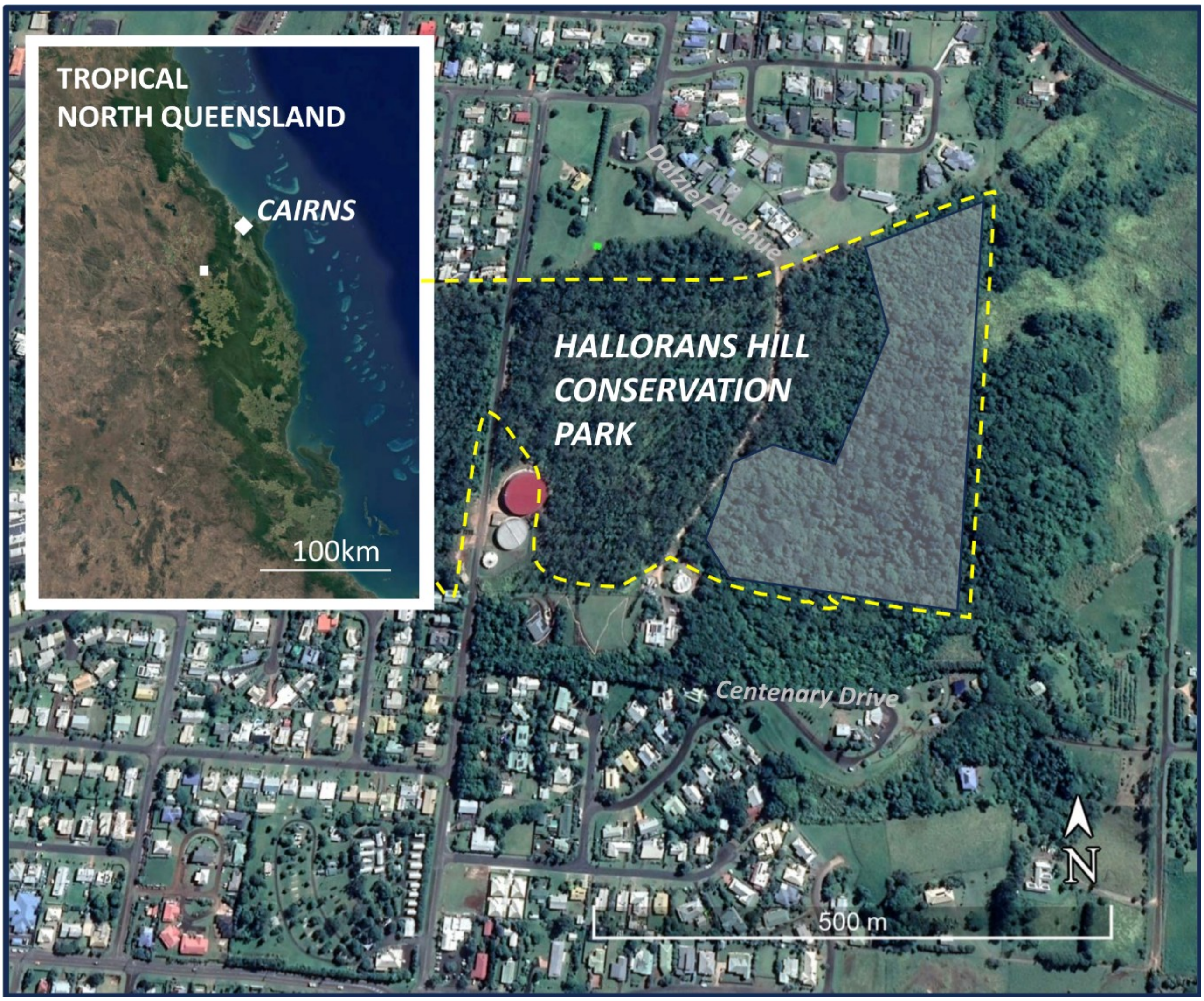

Figure 1. The study area in eastern portion of Hallorans Hill Conservation Park, Atherton, Queensland. Inset map shows the broader tropical north Queensland region and the approximate location of the study area (white square) relative to the city of Cairns. The yellow outline denotes the boundary of conservation park (western section not shown) and the transparent grey area is a ~6 ha patch of Mabi forest which was the focal area of the bryophyte sampling.

that of other volcanic landforms such as the Seven Sisters and Quincan Crater which are 6.5 km and 10.1 km due east (Department of Environment and Science 2020). Within the park, there is also a small seasonal creek which flowsmore or less in north to south direction, and also Priors Creek that runs east to west in the western part of the conservation park. The park is a popular day use location accessible by Dalziel Avenue to the west and Centenary Drive to the south (Fig. 1).

The remnant patch of ~6 ha of Mabi forest vegetation in Hallorans Hill Conservation Park is characterized by having a 25 – 40 m canopy with a component of deciduous and semi-deciduous trees such as *Toona ciliata* (Red Cedar) and *Melia azedarach* (White Cedar), the presence of robust lianas, a well-defined shrub layer, and conspicuous plank roots on some canopy trees (e.g. *Dysoxylum* [mahogany] spp. and *Ficus* [fig] spp.). These structural descriptors apply well to the forests accessed from the west by Dalziel Avenue. However, towards the summit along Centenary Drive, the forest vegetation is shorter, with a canopy of 10 – 15 m. The Mabi forest also extends east into private property, which we did not sample. The park is flanked by residential areas to the north and south, pasture or farmland to the east, and includes eucalypt or ecotonal forest dominated by *Eucalyptus tereticornis* (Forest Red Gum) and *Corymbia intermedia* (Pink Bloodwood) to the west.

Bryophyte surveys

Prior to the start of field sampling, we attempted to collate additional records by searching databases such as the Atlas of Living Australia (Belbin *et al.* 2021) but there were no bryophyte records for Hallorans Hill. In a further search in the Australian Virtual Herbarium (AVH 2025), we found five old bryophyte records from 1968 at the general locality of Hallorans Hill Conservation Park, but we do not include these records in our results (see Discussion). In 2013, Andi Cairns and David Meagher collected and identified 26 bryophyte specimens which we later included in the results.

We conducted our sampling over three days during the wet season in March 2023. On each sampling day, four collectors spread out to collect bryophytes within the study area. While our focus was on rainforest bryophytes, we also sampled along the margins of the forest and in the open and human-managed grassy areas along Centenary Drive, and at the public barbeque area at the lookout point (Fig. 1). Bryophytes were collected following a floristic habitat sampling method, which involves examining all available substrates (Fig. 2) and collecting thoroughly until no new species are found (Newmaster *et al.* 2005). The substrates sampled included tree trunks (up to the maximum safe sampling height of 2 m; Fig. 2A), accessible twigs or small stems, root bases and plank root flanges, soil (Fig. 2B), rocks (Fig. 2C), tree stumps (Fig. 2D), fallen logs, and leaf surfaces (Fig. 2E). Fallen limbs or twigs with bryophytes or leaf bases of basket-like ferns were also examined as a representation of bryophyte diversity in the canopy. The substrate type was also used to classify the collections into broad growth habits: epiphytic (on tree bark or twigs); epixylic (on dead wood or decomposing logs); terrestrial (on soil), epilithic (on rock); and epiphyllous (on leaves). In total, our sampling effort in the field consisted of at least 48 person-hours.

Bryophytes were collected in paper collection envelopes, with the collection date and substrate type recorded. Geographical coordinates of collections were recorded using a Garmin GPSMAP 64 GPS unit (± 5-10 m accuracy). For most collections, we also took photographs on either an iPhone or a Nikon D3200 camera (AF Micro-Nikkor 60mm lens) before collection. During the survey, we made multiple collections of many species even if we had already collected similar looking species. We opted for such a collecting strategy for thoroughness as a species may occupy more than one substrate, and because it is in line with the floristic habitat sampling method (Newmaster *et al.* 2005). In the field, a hand lens was used to ascertain if specimens had been previously observed and, when possible, to verify their identity as either a moss, liverwort, or hornwort. After collection, the samples were brought to the School for Field Studies Australia campus (24 km from Hallorans Hill) for identification. All collections were made under a permit (Authority No. P-PTC-100154422) authorizing David Tng to collect herbarium samples, and duplicate samples will be submitted to the Queensland Herbarium later.

Specimen identification

In the laboratory, the bryophyte collections were organised into mosses, liverworts, and hornworts. Samples were first examined under an Optico ASZ 400 stereoscope at 10-45x magnification. For most of the specimens we examined, individual leaves were excised with fine forceps and a wet mount was made to examine leaf cellular features at 100x, 400x and 1000x magnification for identification. After examination, samples were left in their paper envelops to air-dry for a day, and then transferred into new labelled paper envelopes.

Bryophytes were identified using relevant taxonomic keys and specialist literature. For mosses, we used taxonomic keys available on the Australian Mosses Online website (Australian Biological Resources Study 2016) and other supplementary and updated taxonomic literature for specific moss taxa in the Calymperaceae (Seppelt *et al.* 2021, 2022), Lembophyllaceae (Meagher *et al.* 2020), Leucobryaceae (Tiwutanon *et al.* 2023), Pterobryaceae (Yu & Jia 2015), and Ptychomniaceae (During 1977). For liverworts, we relied on liverwort keys in Jackes and Cairns (2001), Lee and Gradstein (2021) and an informal liverwort key for the region written by David Meagher (unpublished manuscript). Updated keys for specific liverwort genera such as *Bazzania* (Meagher 2019) and *Plagiochila* (Renner 2018) were also consulted. The nomenclature in this paper follows those of Renner *et al.* (2024) for hornworts and liverworts, and Cairns *et al.* (2019) for mosses.

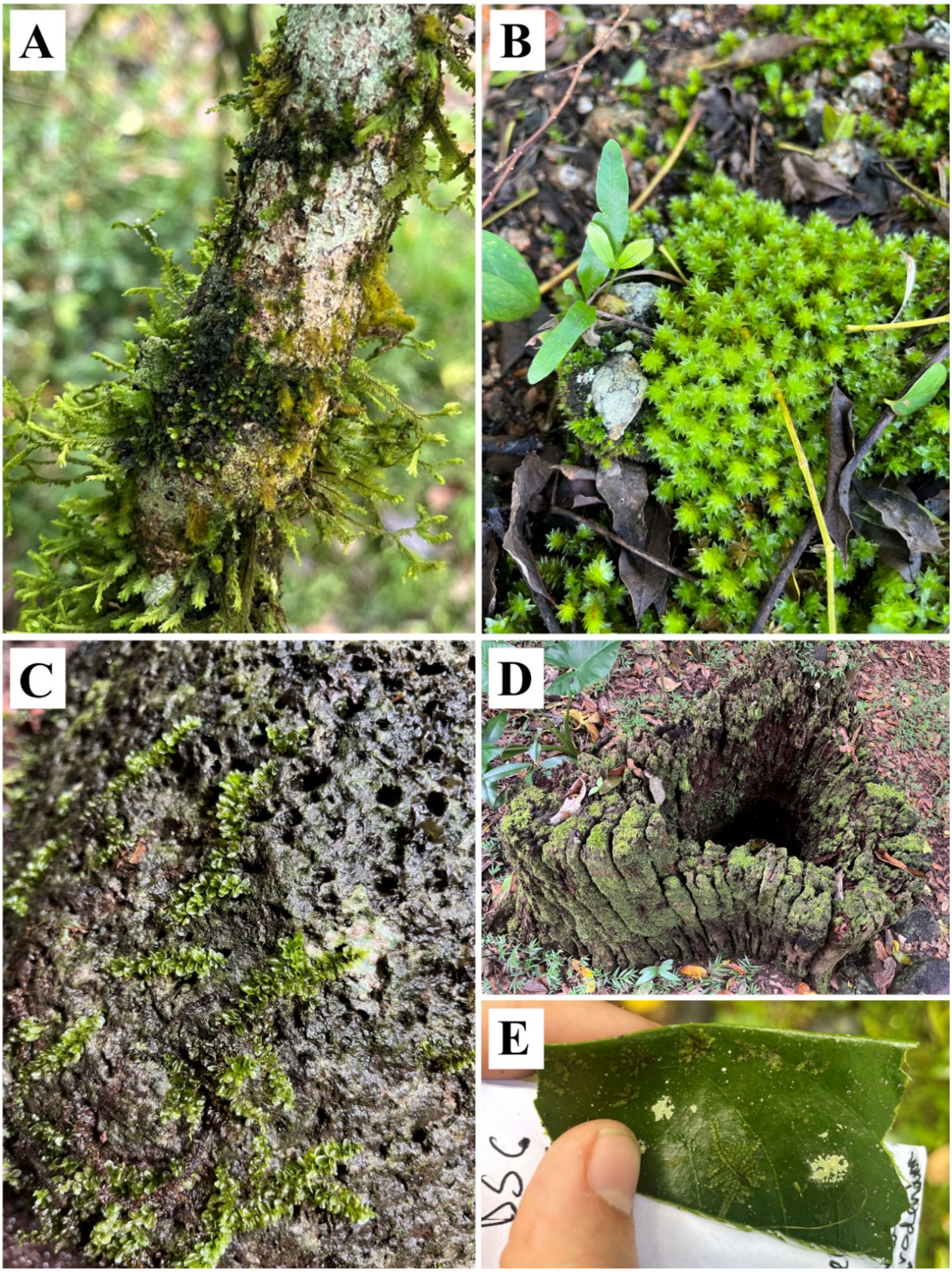

Figure 2. Bryophyte substrates sampled in Mabi forest on Hallorans Hill, Atherton, Queensland. A. living tree bark with epiphytic *Plagiochila* spp. and other liverworts; B. ground/soil with terrestrial *Rosulabryum albolimbatum* moss growing among leaf litter; C. rock surfaces featuring epilithic *Orthomnion elimbatum* moss; D. decaying logs/tree stumps with a variety epixylic mosses and liverworts; E. living leaf surfaces with epiphyllous liverworts from the Lejeuneaceae family. Photos: Camilla Mancini, Zoe Strothkamp and Aidan Nelsen.

Results

Bryophyte diversity

We collected a total of 202 specimens, consisting of 87 distinct taxa of bryophytes (two hornworts, 41 liverworts, and 44 moss species; Table 1 & Appendix 1). Among these, one liverwort (*Mastigolejeunea humilis*) and four mosses (*Cryphaea tenella*, *Entodon spicatus*, *Macromitrium ligulaefolium*, *Pterobryidium australe*) were observed by Cairns and Meagher in 2013 but not collected in this study.

The two hornwort species consisted of one species identified to the genus *Phaeoceros* (Notothyladaceae) and the other identified as *Anthoceros punctatus* (Anthocerotaceae). Liverwort species consisted of 20 genera in 9 families (Table 1) with representatives of both complex thalloid (Marchantiopsida) and leafy (Jungermanniopsida) orders. Eleven liverwort taxa were identified to genus and distinguished as unique morphospecies, and eight were identified only to family (Appendix 1). Four species of liverworts were thalloid (*Riccardia* sp., *Riccia cartilaginosa*, *Riccia* sp. and *Metzgeria furcata*; Fig. 3A,B) but the rest were leafy. The liverwort family with the greatest numbers of species was Lejeuneaceae, with 26 unique taxa. Of these, the genus *Cheilolejeunea* (Fig. 3C,D) was the most species-rich with five unique taxa (Appendix 1). The next most diverse family was Frullaniaceae with four species of *Frullania* (Fig. 3E,F).

Mosses consisted of 34 genera in 21 families, with three morphospecies not identified to genera or family (Table 1 & Appendix 1). Among these families, the Meteoriaceae and the Pterobryaceae had the highest representation (both with four species; e.g. see *Meteorium polytrichum* and *Muellerobryum whiteleggei*; Fig. 4A,B respectively). The most species rich genus was *Fissidens* (e.g. *Fissidens crispulum*; Fig. 4C), which consisted of at least three species (Appendix 1).

Growth habit and substrate use

Most of the bryophytes collected grew on the bark of living trees (epiphytic), followed by on rocks (epilithic), on decaying wood (epixylic), and on soil (terrestrial) (Table 2 & Appendix 1). The same general patterns were observed when looking at liverworts or mosses individually (Table 2). Three species of liverworts exhibited the epiphyllous habit (growing on leaf surfaces) but none of the mosses were found with this growth habit (Figure 2E, Table 2, Appendix 1). Almost 30% of the bryophyte species exhibited multiple growth habits, but mosses appeared to be less bound to a particular growth habit than liverworts (Table 2 &Appendix 1).

Seven species (8% of the total species) occurred only in exposed or anthropogenically maintained forest edges. Specifically, the two terrestrial species of hornworts and the two species of *Riccia* (Appendix 1) were found growing in soil near the forest edge, while three mosses including *Bryum argenteum*, *Gemmabryum* sp. and *Tortula* sp. were found in exposed areas on bitumen or on cobblestones in a public barbeque area.

Discussion

Through our preliminary baseline survey of Mabi forest and marginal habitats at Hallorans Hill Conservation Park, we found almost 90 species of bryophytes, laying the foundation for further bryophyte research in the area. Considering that the Wet Tropics bioregion has a record of slightly over 410 moss taxa (Cairns *et al.* 2019) and a similar number of liverwort taxa (Renner *et al.* 2024), the 87 taxa we found would constitute approximately a tenth of the bryophyte species recorded in the bioregion.

Table 1. Taxonomic summary of bryophytes collected from Mabi forest on Hallorans Hill, Atherton, Queensland. See Appendix 1 for full list.

Classification	No. of families	No. of genera	No. of unique taxa
Anthocerotophyta (hornworts)	2	2	2
Marchantiophyta (liverworts)	9	20	41
Class: Marchantiopsida (Complex thalloid liverworts)	1	1	2
Class: Jungermanniopsida (Leafy & simple thalloid liverworts)	8	19	39
Bryophyta (mosses)	21	34	44

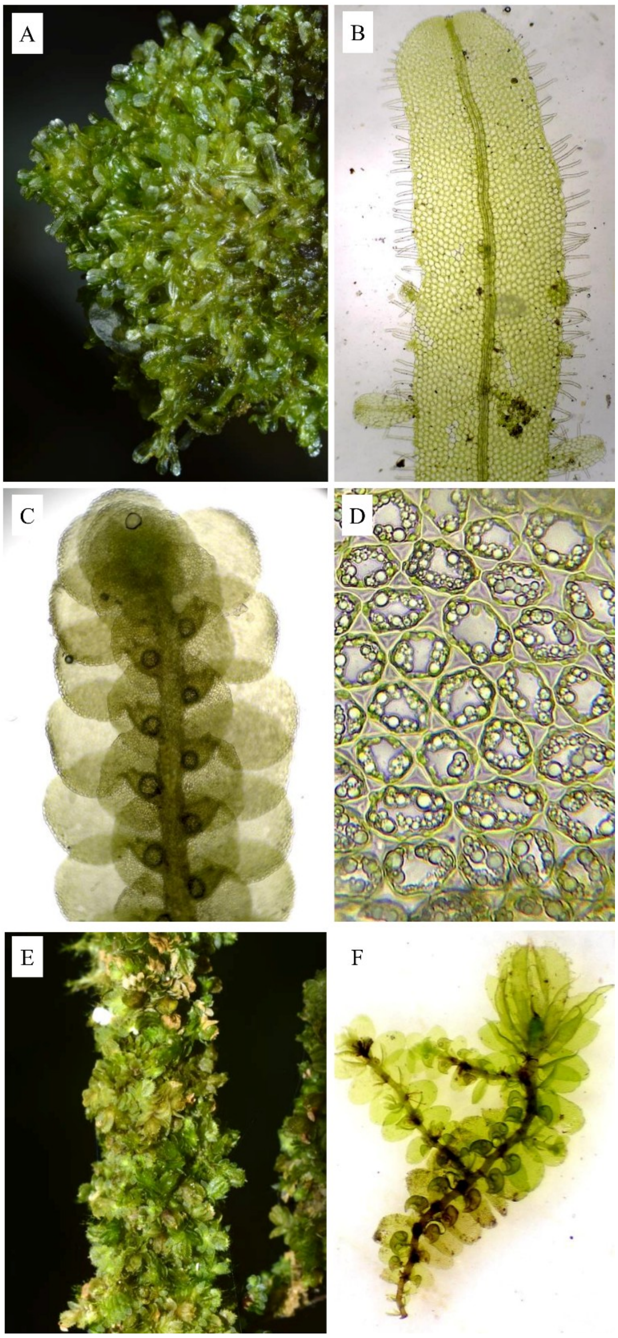

Figure 3. Liverworts found in Mabi forest on Hallorans Hill, Atherton, Queensland.
A. *Metzgeria furcata* (Metzgeriaceae), an epiphytic thalloid liverwort; B. *M. furcata* thallus; C. ventral view of the leafy liverwort *Cheilolejeunea trifaria* (Lejeuneaceae); D. *C. trifaria* leaf cell details exhibiting granular cell inclusions (oil bodies) and huge trigones (cellular thickenings at cell corners); E. the leafy liverwort *Frullania monocera* (Frullaniaceae) growing adpressed on a small twig. Perianths were abundant on the specimen; and F. ventral view of the shoot of *F. monocera* showing the helmet-shaped lobules. Photos: David Tng, Camilla Mancini, Zoe Strothkamp and Aidan Nelsen.

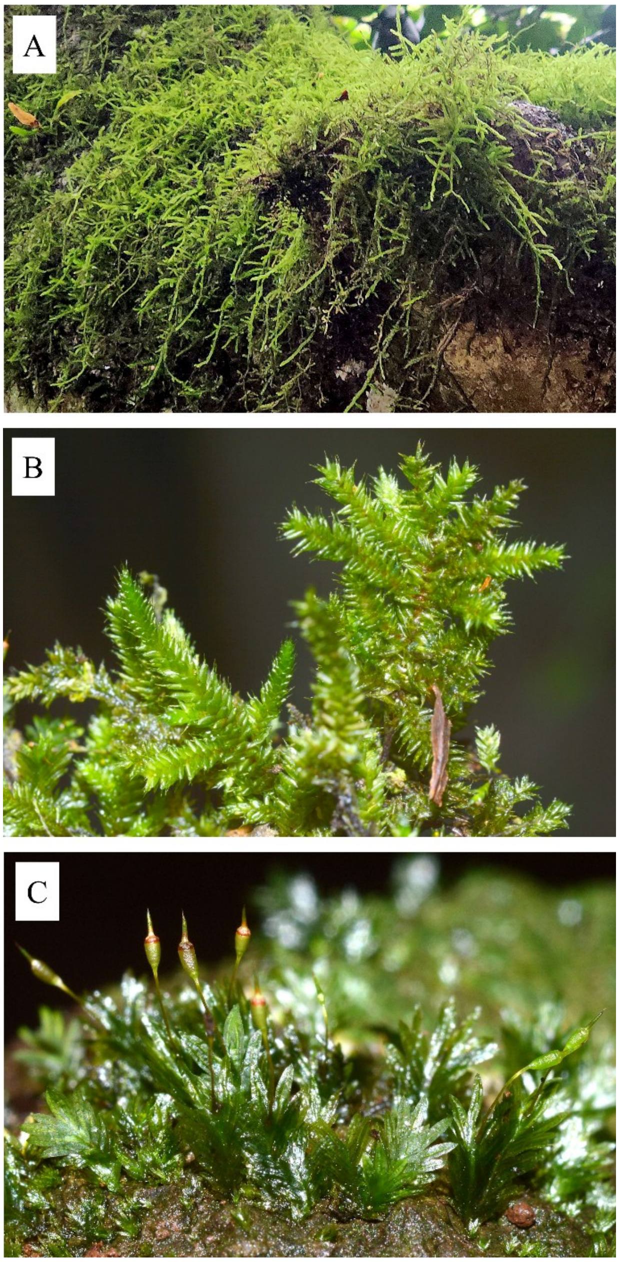

Figure 4. Mosses found in Mabi forest on Hallorans Hill, Atherton, Queensland.
A. *Meteorium polytrichum* (Meteoriaceae), an epiphytic and pendant moss growing on a branch of a fig (*Ficus*) tree; B. Closeup of the shoots of *Muellerobryum whiteleggei* (Pterobryaceae), an epiphytic moss; C. Turf-forming moss *Fissidens crispulum* (Fissidentaceae) on rock showing distinctive distichous and plane shoots and capsules. Photos: David Tng.

The history of bryophyte sampling at the locality and how it relates to our current survey is worth a mention. During our preliminary search on the Atlas of Living Australia, we found no records for the locality. In another search in the Australian

Table 2: Growth habit of bryophytes collected from Mabi forest on Hallorans Hill, Atherton, Queensland. Growth habits include: epiphytic (on tree bark or twigs); epixylic (on dead wood or decomposing logs); terrestrial (on soil), epilithic (on rock); and epiphyllous (on leaves) (See Fig. 2). See also Appendix 1 for the growth habits of individual species. The two hornworts were both terrestrial.

Growth habit	No. of bryophyte species (%)	No. of liverwort species (% of liverworts)	No. of moss species (% of mosses)
Epiphytic	58 (66.7%)	26 (63.4%)	32 (72.7%)
Epilithic	36 (41.4%)	10 (24.4%)	26 (59.1%)
Epixylic	27 (31.0%)	11 (26.8%)	16 (36.4%)
Terrestrial	11 (12.6%)	2 (4.9%)	7 (15.9%)
Epiphyllous	3 (3.4%)	3 (7.3%)	0
Multiple	26 (29.9%)	7 (17.1%)	19 (43.2%)

Virtual Herbarium, we found five bryophyte collection records in 1964 by Dutch botanist Bernard Otto van Zanten which fell within a one-kilometre radius of Dalziel Avenue and which encompasses our entire sampling area (AVH 2025). These specimens belong to four moss species, *Campylopus perauriculatus* (2 records), *Calyptrochaeta brassii*, *Dawsonia polytrichoides* and *Trachyloma diversinerve*, none of which were recorded during the brief survey by Cairns and Meagher in 2013, or during the current survey. We did not include these old records in the current study because there is a level of uncertainty regarding their geolocations and we could not be sure that these specimens were collected within the rainforest patch we sampled. It would be worth relocating these species in the area.

The finding of a diverse bryophyte flora on a ~6 ha remnant patch of Mabi forest has important implications for conservation. Bryophytes carry out a variety of ecosystem functions, including nutrient and carbon cycling, regulating soil temperature and water retention, and influencing soil micro-organisms (Clark *et al.* 2005; Spangler 2021). Additionally, bryophytes serve as habitats for many micro- and macro-invertebrates, including some that live only on or rely on bryophytes (Glime 2017). For example, we encountered several invertebrates when examining our samples under the microscope, including an unidentified mite, eggs of unknown origin, and a living tardigrade.

Despite their value to the ecosystems they are a part of, bryophytes are seldom included in vegetation surveys (but see Tomasko *et al.* 2024) or given any consideration during the preparation of recovery plans for specific vegetation types in Queensland. For instance, the Queensland Environmental Protection Agency's recovery plan for Mabi forest references the more than 550 vascular plants that have been identified as native to the Mabi forest as a reason for its protection, but contains no references to the many native non-vascular plant species such as bryophytes (Latch 2008). Vegetation surveys including non-vascular plants can be used to bolster the biodiversity values of the vegetation at a given locality (e.g. Tomasko *et al.* 2024), and the data from this work could also serve as a basis for comparing non-vascular and overall plant diversity between Mabi fragments. Since bryophytes are indicators of forest integrity (Frego 2007; Pakeman *et al.* 2019), studies on bryophytes at different Mabi forest patches could serve as useful indicators for monitoring the ecological health of these forest fragments.

Substrate specificity is an important aspect of bryophyte ecology and important information for informing conservation actions (Tng *et al.* 2009; Wysocki *et al.* 2024) but remains understudied in the Wet Tropics. While our study demonstrates that even a remnant patch of rainforest can have a relatively species rich bryophyte flora occupying various substrates, more research on bryophyte substrate use and general ecology in the Wet Tropics is needed. Potential directions of future ecological research include investigating the vertical stratification of bryophyte life forms, a phenomenon recorded in various climates but lacking data in the Wet Tropics (Sporn *et al.* 2010; Gehrig-Downie *et al.* 2013), quantifying bryophyte phytomass in tropical rainforests (e.g. Frahm 1990; Glime 2024), and assessing the potential for particular species or bryophyte communities to be indicators of forest development or climate change (Gignac 2001; Frego 2007). Comparative studies of rainforest types are especially critical, particularly endangered ecosystems such as Mabi forest, and other rainforest types in lowland and upland regions (Ramsay & Cairns 2004; Tomasko *et al.* 2024).

Conclusions

Mabi forests are among the most threatened types of rainforest ecosystems in Australia. Although their vascular flora is well documented, little is known about the bryophyte flora of these forests. In our preliminary survey of the Mabi forests at a small remnant patch (~6 ha) in Atherton, we found a high diversity of over 80 species of bryophytes inhabiting a range of different substrates. These results help to fill gaps in our knowledge of the biodiversity values of Mabi forests and highlight the need for more systematic surveys of remnant forests and other rainforest vegetation in general in the Australian Wet Tropics. There is also a need for more distributional data for individual bryophyte species to be able to inform their conservation status.

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Appendix 1.

List of bryophyte species collected from Mabi forest on Hallorans Hill, Atherton, Queensland, along with their growth habit. Asterisks (*) following the species name indicate a species that was also found during an informal survey of Hallorans Hill by Andi Cairns and David Meagher in 2013. Growth habit definitions are as follows: *epiphytic* – living on trees, *epilithic* – rock dwelling, *terrestrial* – ground/soil dwelling, *epixylic* – living on decaying logs/tree stumps, *epiphyllous* – living on leaf surfaces.

Family and higher-order classification	Species	Growth Habit
Hornworts (Anthocerotophyta)		
Anthocerotaceae	*Anthoceros punctatus*	terrestrial
Notothyladaceae	*Phaeoceros* sp.	terrestrial
Liverworts (Marchantiophyta)		
Aneuraceae	*Riccardia* sp.	epixylic
Frullaniaceae	*Frullania hypoleuca*	epiphytic
Frullaniaceae	*Frullania monocera*	epiphytic, epixylic
Frullaniaceae	*Frullania rubella*	epiphytic, epilithic
Frullaniaceae	*Frullania yorkiana*	epiphytic, epiphyllous
Lejeuneaceae	*Acrolejeunea pycnoclada*	epiphytic
Lejeuneaceae	*Cheilolejeunea trifaria*	epiphytic
Lejeuneaceae	*Cheilolejeunea* sp. 1	epiphytic
Lejeuneaceae	*Cheilolejeunea* sp. 2	epiphytic
Lejeuneaceae	*Cheilolejeunea* sp. 3	epiphytic
Lejeuneaceae	*Cheilolejeunea* sp. 4	epiphytic
Lejeuneaceae	*Cololejeunea cardiocarpa*	epiphyllous
Lejeuneaceae	*Cololejeunea lanciloba*	epiphyllous
Lejeuneaceae	*Drepanolejeunea* sp. 1	epiphytic
Lejeuneaceae	*Drepanolejeunea* sp. 2	epiphytic
Lejeuneaceae	*Leptolejeunea maculata*	epiphyllous
Lejeuneaceae	*Lopholejeunea* sp.	epiphytic
Lejeuneaceae	*Mastigolejeunea humilis**	epiphytic
Lejeuneaceae	*Microlejeunea* sp.	epiphyllous
Lejeuneaceae	*Spruceanthus thozetianus*	epilithic, epiphytic
Lejeuneaceae	*Thysananthus spathulistipus*	epiphytic
Lejeuneaceae	*Lejeunea* sp 1	epiphytic
Lejeuneaceae	*Lejeunea* sp 2	epixylic
Lejeuneaceae	Lejeuneaceae sp indet 1	epilithic
Lejeuneaceae	Lejeuneaceae sp indet 2	epixylic
Lejeuneaceae	Lejeuneaceae sp indet 3	epiphytic
Lejeuneaceae	Lejeuneaceae sp indet 4	epiphytic
Lejeuneaceae	Lejeuneaceae sp indet 5	epiphytic
Lejeuneaceae	Lejeuneaceae sp indet 6	epiphytic
Lejeuneaceae	Lejeuneaceae sp indet 7	epiphytic
Lejeuneaceae	Lejeuneaceae sp indet 8	epixylic
Lepidoziaceae	*Bazzania francana*	epixylic
Lepidoziaceae	*Bazzania mittenii*	epixylic
Lepidoziaceae	*Lepidozia* sp.	epixylic
Lophocoleaceae	*Lophocolea semiteres*	epixylic
Metzgeriaceae	*Metzgeria furcata*	epiphytic
Plagiochilaceae	*Plagiochila acutifolia*	epiphytic, epixylic
Plagiochilaceae	*Plagiochila* sp.	epiphytic, epixylic

Porellaceae	*Porella crawfordii**	epiphytic, epilithic
Ricciaceae	*Riccia cartilaginosa*	terrestrial
Ricciaceae	*Riccia* sp.	terrestrial
Mosses (Bryophyta)		
Bartramiaceae	*Philonotis hastata*	epiphytic
Bryaceae	*Bryum argenteum*	terrestrial, epilithic
Bryaceae	*Gemmabryum* sp 1	terrestrial, epilithic
Bryaceae	*Rosulabryum albolimbatum**	terrestrial, epilithic, epiphytic
Calymperaceae	*Syrrhopodon armatus*	epixylic
Calymperaceae	*Syrrhopodon parasiticus*	epiphytic
Cryphaeaceae	*Cryphaea tenella**	epiphytic
Entodontaceae	*Entodon plicatus **	epiphytic
Fissidentaceae	*Fissidens crispulus*	epiphytic, epilithic, epixylic
Fissidentaceae	*Fissidens linearis*	epilithic
Fissidentaceae	*Fissidens tenellus*	epiphytic
Hypnaceae	*Hypnum cupressiforme*	terrestrial, epilithic, epixylic, epiphytic
Hypnodendraceae	*Hypnodendron spininervium*	epiphytic, epixylic, epilithic
Hypopterygiaceae	*Hypopterygium tamarisci*	epilithic, epiphytic
Hypopterygiaceae	*Lopidium struthiopteris**	epiphytic, terrestrial
Lembophyllaceae	*Camptochaete excavata*	epiphytic
Lembophyllaceae	*Camptochaete subporotrichoides*	epixylic, epiphytic
Leucobryaceae	*Campylopus catarractilis*	epixylic
Leucobryaceae	*Leucobryum scalare*	epiphytic, epixylic
Meteoriaceae	*Aerobryopsis longissima*	epilithic
Meteoriaceae	*Meteoriopsis reclinata**	epiphytic
Meteoriaceae	*Meteorium polytrichum**	epiphytic, epixylic
Meteoriaceae	*Papillaria nitens*	epiphytic, epixylic, epilithic,
Mniaceae	*Orthomnion elimbatum**	epilithic
Neckeraceae	*Circulifolium exiguum*	epiphytic
Orthotrichaceae	*Macromitrium ligulaefolium**	epiphytic
Orthotrichaceae	*Macromitrium* sp. aff. *repandum*	epilithic, epiphytic, epixylic
Orthotrichaceae	Orthotrichaceae sp indet. 1	epixylic
Orthotrichaceae	Orthotrichaceae sp. indet. 2	epilithic
Pottiaceae	*Barbula* sp.	terrestrial
Pottiaceae	*Tortula* sp. aff. *truncata*	epilithic, epiphytic
Pterobryaceae	*Calyptothecium recurvulum*	epiphytic
Pterobryaceae	*Calyptothecium urvilleanum**	epiphytic, epilithic
Pterobryaceae	*Muellerobryum whiteleggei**	epixylic, epiphytic
Pterobryaceae	*Pterobryidium australe **	epiphytic, epilithic
Ptychomniaceae	*Garovaglia elegans* subsp. *dietrichiae**	epiphytic, epilithic
Ptychomniaceae	*Euptychium setigerum*	epiphytic
Racopilaceae	*Racopilum cuspidigerum*	epilithic, epiphytic
Sematophyllaceae	*Sematophyllum subpinnatum**	epiphytic
Thuidiaceae	*Pelekium velarum*	epiphytic
Thuidiaceae	*Thuidiopsis sparsa**	terrestrial
Moss indet	sp. indet 1	epiphytic
Moss indet	sp. indet 2	epixylic
Moss indet	sp. indet 3	epiphytic